Lessons Learned on Home Energy Monitoring and Management: Smartcity Málaga

Jaime Caffarel, Igor Gómez, Guillermo del Campo, Rocío Martínez and Carmen Lastres

ABSTRACT
The Smartcity Málaga project is one of Europe's largest eco-efficient city initiatives. The project has implemented a field trial in 50 households to study the effects of energy monitoring and management technologies on the residential electricity consumption. This poster presents some lessons learned on energy consumption trends, smart clamp's reliability and the suitability of power contracted by users, obtained after six months of data analysis.

Categories and Subject Descriptors
J.2 [**Physical Sciences and Engineering**]: Engineering

General Terms
Performance, Reliability, Experimentation

Keywords
Data Analysis, Data Reliability, Energy Consumption, Energy Monitoring.

1. THE SMARTCITY MÁLAGA PILOT
The Smartcity Málaga project aims to concentrate a wide range of sustainable technologies in the city: smart metering, smart grid, renewable energy generation as well as storage and e-vehicle recharging, among other innovations. Specifically, it evaluates the impact on reducing residential energy consumption by means of improving the energy consumption feedback. In Spain, customers usually receive information about their energy consumption (billing) every two months. Previous reviews [1] report saving up to 15%, while recent projects show effects around 5% [2].

An energy monitoring system consisting of a smart meter, a smart clamp and a set of on-off controllers and power monitoring plugs has been installed and configured in each participant's household. The end user has access to instant and average energy consumption and configuration information via smartphone and over the Internet.

Moreover, through an acquisition, storage and exploitation system (DASE), all the configuration values, together with hourly energy measurements, historic and current billing data, weather information and working calendar have been stored in a relational database.

Based on a segmentation process, an initial group of 50 participants were identified, according to their power consumption and higher technical knowledge. Finally, only 25 users that had more than 75% of right measurements (i.e. without long term disconnection of devices) were retained for analysis. The trial field phase started in December 2011 and ended in December 2012. In this poster, we present the structure of the DASE along with the results from the data analysis corresponding to the first semester of year 2012.

2. DATA ACQUISITION, STORAGE AND EXPLOITATION SYSTEM
As a first step, collecting and formatting all the relevant information (i.e. metering, billing, configuration and weather) has been necessary to perform a reliable analysis.

Each data source has a different format (XML, CSV and XLS), structure and time stamp. Using the DataStage tool (IBM), information is collected, transformed and stored in a database. A relational database was designed and implemented using the DB2 tool (IBM). Cognos tool (IBM) has been used to represent both numerically and graphically all the information. This visualization process has allowed the identification and correction of erroneous data.

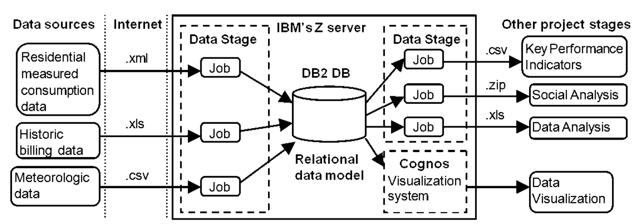

Figure 1. DASE system

In addition, error-free data is exported and sent daily to other systems for further analysis and exploitation (i.e. calculation of key performance indicators or statistics).

3. RESULTS AND DISCUSSION

Preliminary results obtained from the data analysis covering from 1st January 2012 to 30th June 2012 are presented in the following sections.

3.1 Consumption trend

Billing data has been compared to the mean of historic billing data (2008-2011 mean) to evaluate the consumption trend of the participants. 42% of participants have achieved a remarkable consumption reduction (above 10%) while 33% have kept their previous consumption level (within ±10%). The remaining 25% have increased their consumption more than 10% (see fig 2).

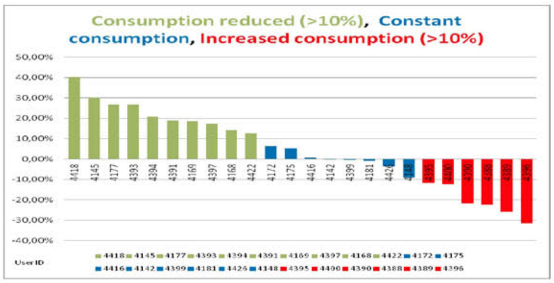

Figure 2. Consumption trend by participant (%)

Setting aside the behavior of each participant it is difficult to assure that the consumption reduction was motivated by the use of the installed devices. It could have been motivated by exogenous causes such as the economic crisis, variations in the number of occupants or the substitution of electric appliances for more efficient ones.

3.2 Contracted power

The maximum power to be contracted by a user is usually estimated by considering the maximum power of the appliances in the home and the patterns of use. The availability of real hourly energy consumption suggested the possibility of contrasting the power contracted by users with real energy measurements.

Considering the total amount of hourly consumption values, we have represented a histogram for each participant. The histogram intervals correspond to the increments for contracted power available in Spanish contracts (1.1kW). Assuming the maximum power demand is covered when 99% of measurements are below a certain level, 70% of participants would be able to reduce their contracted power in at least one step. However, there are some types of electrical appliances such as washing machines or HVAC systems whose peak consumption is not well represented by hourly measurements. Increasing the measurement frequency, (e.g. to 15 minutes) would help to better validate the suitability of this analysis.

3.3 Data reliability

When providing measurements for external use and analysis, data reliability is a must. Detecting errors and identifying the causes (e.g. measurement or communication failures, devices disconnection, etc.) has helped us to automate pre-storage and pre-exploitation processes. On the other hand, the detection of anomalous behaviors and malfunction of devices has been used to select the participants to be considered qualified for the project. The majority of the problems were caused by the disconnection of gateways, reflected by the system as “no data”.

4. CONCLUSIONS

The pilot of the Smart City Project in Málaga has provided a good set of lessons learned for future applications in new pilot projects.

In the first place, we must note the difficulty of drawing conclusions on energy consumption variations related to the implementation of energy monitoring technologies. In a real-life pilot, many other factors can cause these changes: climate fluctuations in different years, economic and social circumstances of end users, occupancy of households, etc.

Another added value provided by detailed monitoring is the possibility of optimizing users’ type of contract and utilities’ sizing of the network by estimating the optimum contracted power. This estimation could be improved using 15 minutes rate measurements or peak power meters.

Finally, it is necessary to take into account that some smart clamps used for in-home monitoring do not have as much accuracy as the smart meters. Consequently, they are suitable to provide energy feedback to users, but not for billing purposes. Their suitability for specific demand-response services should be further investigated. However, the interviews with participants have yielded alternative uses of the devices, not only for energy monitoring, but also for remote management and supervision of their homes.

5. ACKNOWLEDGMENTS

Authors would like to thank Endesa for the support provided during the project and CDTI and FEDER for the funding of the SmartCity Málaga project.

6. REFERENCES

[1] C. Fischer, “Feedback on household electricity consumption: A tool for saving energy?” *Energy Efficiency 1*, 79-104, 2008.

[2] Schleich, J.; Klobasa, M.; Golz, S., "Does smart metering reduce residential electricity demand?," *European Energy Market (EEM), 2012 9th International Conference on the* , vol., no., pp.1-4, 10-12 May 2012
doi: 10.1109/EEM.2012.6254779